GeoClutter Seabed Reflection and Scattering Measurements

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LONG TERM GOALS

The long term goal is to improve performance of low-mid frequency active sonar systems operating in littoral regions. One of the most serious problems for employment of active sonars is the overwhelming number of clutter events, many of which come from geologic features on and in the seabed.

OBJECTIVES

The objectives of the three-year effort are to identify the geologic features and the associated physical mechanisms that lead to geologic clutter in littoral environments and obtain the physical descriptors of the seabed environment (geoacoustic properties) required for physics-based modeling.

APPROACH

The specific approach for FY02 is to process and analyze reflection and scattering data from prior experiments (GeoClutter and Boundary Characterization). A self-consistent approach is being forged, wherein the geoacoustic basis of the reflection and scattering data are treated in a unified fashion. The approach also includes analysis of geologic/geophsyical data to identify potential geoclutter mechanisms.

WORK COMPLETED

This project is in its very early phase. Seabed reflection data from GeoClutter and Boundary Characterization Experiments have been analyzed to obtain geoacoustic properties (sound speed, density and attenuation as a function of depth and frequency) for a few key sites. Results will aid in the physics-based modeling and in ongoing experiment planning efforts.

The most exciting result is the identification of submarine mud volcanoes as a source of geoclutter. While mud volcanoes on land have been studied for the past several hundred years, very little is known about the submarine versions, especially in shallow water. What is known is that they are formed generally by the rising of methane through faults in the sediment and can have either a surface or subsurface expression. The discovery of submarine mud volcanoes in the shallow water portion of the Straits of Sicily is surprising and stimulating to the underwater acoustics and geology/geophysics communities.

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RESULTS

Mud volcanoes, which often occur in areas of earthquake activity, originate from thick clay beds, usually erupt along fault lines, and often bubble methane gas, and sometimes oil. In the Mediterranean, large (of order 1000m) mud volcanoes have been studied along the Mediterranean Ridge in water depths of ~2000m. During the Boundary Characterization Experiment in May 2002, seismic reflection data (Fig 1) indicated the presence of mud volcanoes (the 3 conical features between 4.6 and 5.4 km) near the coast of Sicily at 165 m water depth.

Sidescan data (Figure 2) over the northern-most surficial mud volcano reveals that at each feature seen in the low resolution seisimic reflection data, there are actually several clusters of mud volcanoes. Two scales of features are apparent: clusters of truncated cylinders roughly 10 m in diameter rising ~4 meters above the seafloor, and surrounding these, high scattering strength patches of order 50 m in diameter, presumably due to entrained gas in the sediment interstices. Diffuse shadows behind the features appear to be caused by gas rising into the water column.

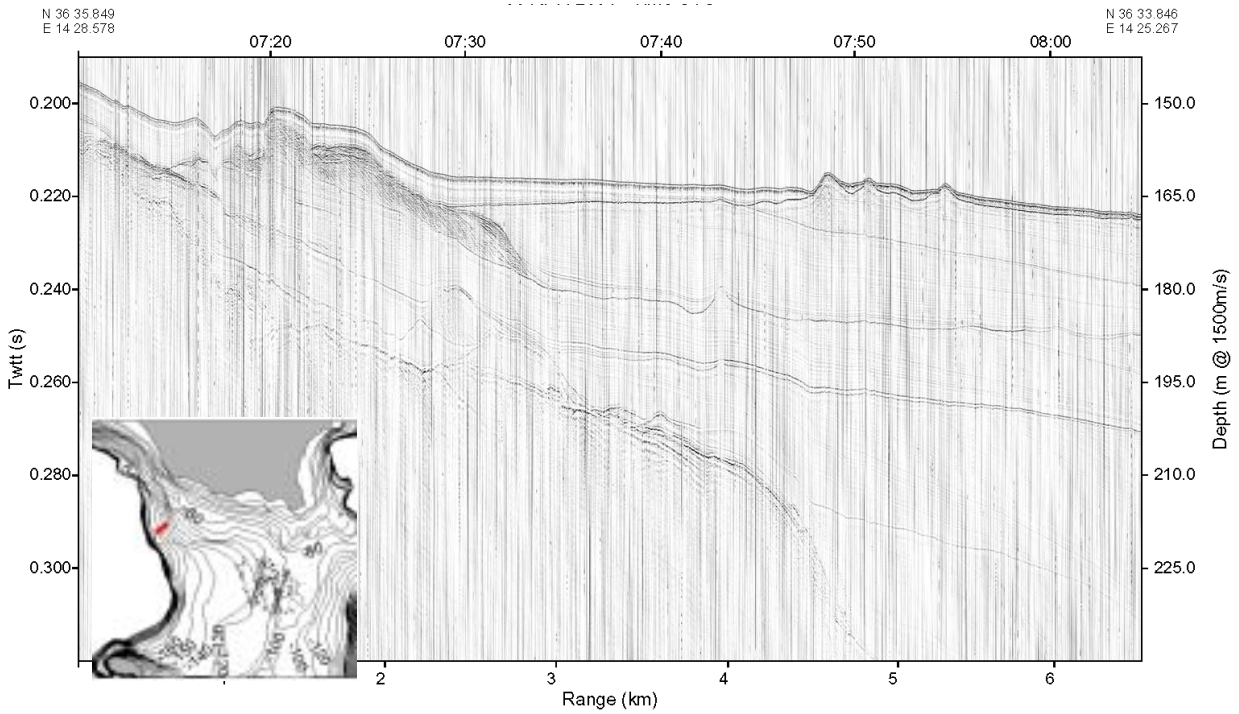

Figure 1. Swell-filtered seismic reflection data on the Malta Plateau. The vertical exaggeration is ~40:1. The mud volcanoes appear in these data as cone-like features (e.g., there are 3 volcanoes between 4.6 and 5.4 km range very close to the water-sediment interface). The inset shows the location of trackline; Sicily is the island to the north and Malta (Gozo) to the south; depth is in meters.

Close examination of the largest feature in Figure 2 indicates possible vent locations either near the center of the truncated cone or on the northwest flank (Figure 3). A curious characteristic of the mud volcanoes are the distinct lineations; the cause of these, whether real or an artifact, is not yet known.

We have strong evidence of broadband clutter from these features. Since the size of the features are comparable to a submarine, they are expected to give rise to false alarms. What is not yet clear is if the scattering is coming from the volcanoes or from the diapirs (the larger bright patches) or perhaps even from expelled gas. The relative roles of the sub-bottom versus the near surface, versus the seafloor piercing volcanoes in generating clutter is also not understood. The presence of sub-bottom mud volcanoes can be clearly seen in Fig 1; there are two buried volcanoes at 4 km range, one ~2 meters sub-bottom and the second ~20 meters sub-bottom; there are several small cones at 20m sub-bottom between 5 and 6.5 km and several cones near the base of the acoustic basement.

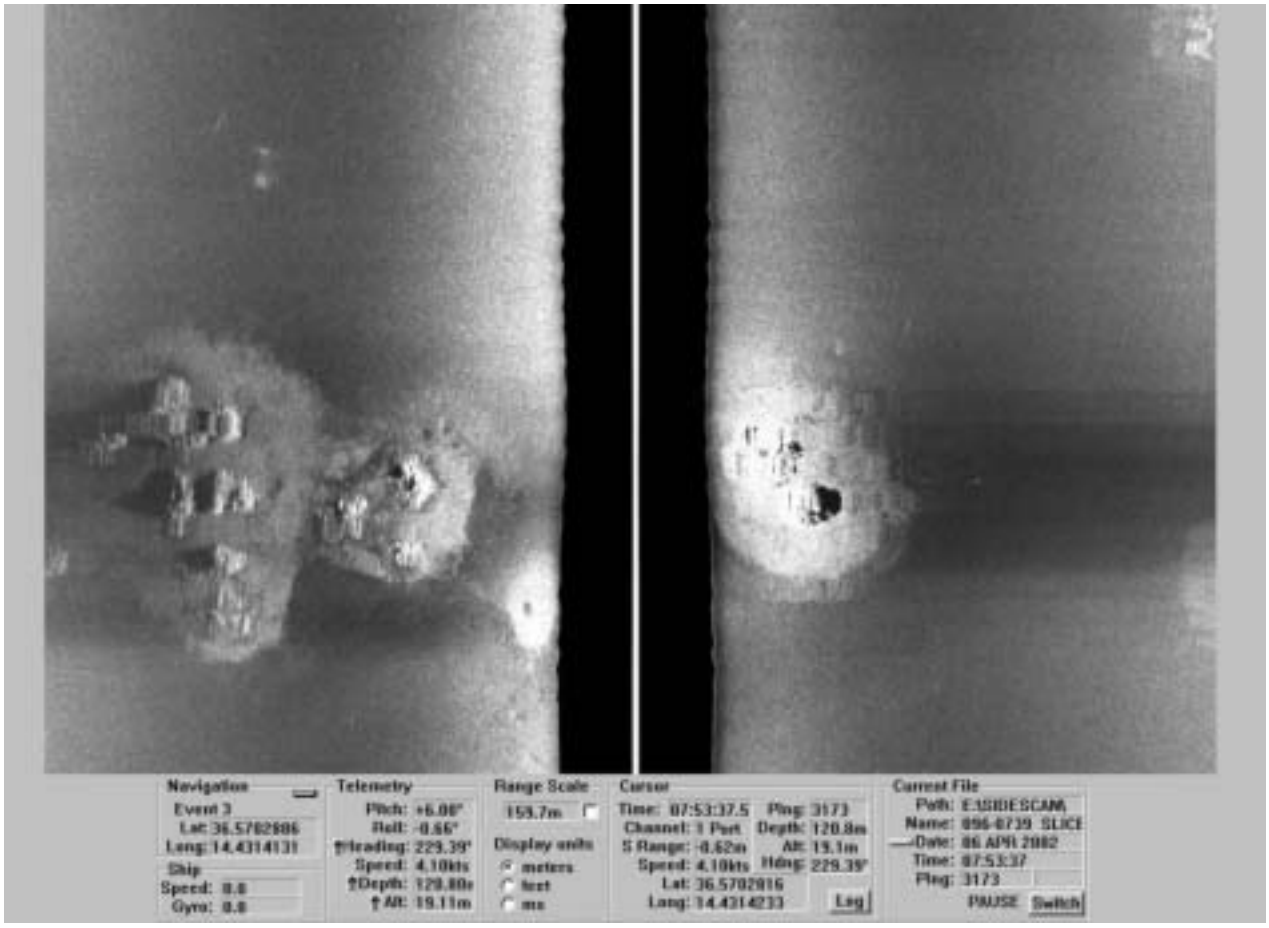

Figure 2. 100 kHz raw sidescan data at the northern mud volcanoes of Figure 2 (at 4.5 km range) showing a cluster of mud volcanoes at this location (the seismic reflection data sensed only the mud volcano closest to the trackline center). The scale is 320 m in cross-range with approximately square pixel size; white indicates high scattering.

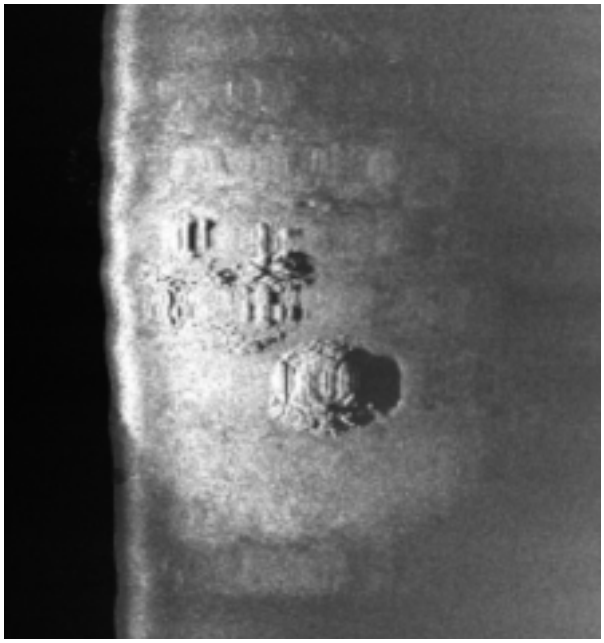

Figure 3. Zoom of raw 384 kHz sidescan data in Figure 15. The scale of the image is about 70x80m. Possible vent locations are near the center of the main feature or near the northwest corner.

IMPACT/APPLICATIONS

The geoacoustic properties at the New Jersey STRATAFORM site will be provided other members of the team for physics-based modeling of the clutter process. This is a key step in refining hypotheses about the mechanisms that give rise to clutter.

The discovery of submarine mud volcanoes in the shallow water portion of the Straits of Sicily is surprising and stimulating to the underwater acoustics and geology/geophysics communities. The importance for active sonar is that these features give rise to false alarms. An interdisciplinary team is being formed to address questions that challenge current assumptions and hypotheses about the history of the Malta Plateau region. The interdisciplinary team will also attempt to obtain sediment entrained gas and expulsed gas estimates as well as to determine the geographic extent, both locally and globally of the mud volcanoes. There are indications that a large number of (as yet uncharted) submarine mud volcanoes exist; thus, understanding characteristics of these mud volcanoes may enhance our ability to predict areas in which they are likely to exist. The biology community is also interested in the mud volcanoes since new life forms are sometimes found in such extreme environments.

RELATED PROJECTS

ONR Uncertainty DRI: Collaborating on marine geologic, geophysical, and geoacoustic data in the New Jersey STRATAFORM area as well as tools to define the uncertainty of these data.

Boundary Characterization Joint Research Project ONR-NATO SACLANT Centre: Providing geologic, geophysical, geoacoustic and acoustic data in the Straits of Sicily.

ONR SWAT Program: Collaborating on geoacoustic inversion results in the New Jersey STRATAFORM area.

I have established contact with a signal processing researcher (Bill Comeau, NUWC) who has also observed significant clutter in this general region during the SWAC trials in the early to mid 90s' to assess how much clutter their system suffered may have come from mud volcanoes.